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(54) **SINGLE FASTENER ELECTRICAL CONNECTOR**

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USPC 439/412, 874, 99, 97, 422, 431, 479, 439/432
See application file for complete search history.

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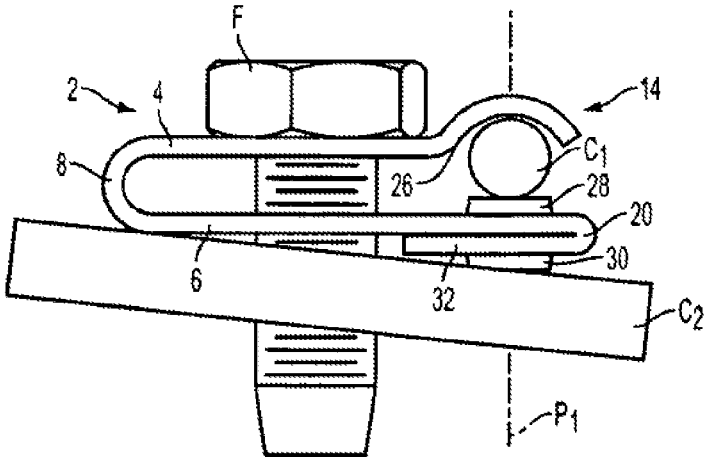
(57) **ABSTRACT**

A one-piece metallic connector is configured to receive a fastener and has features that grip and electrically bond two conductors as they are clamped together when the fastener is tightened. The connector's generally U-shaped body has first and second legs, a bight portion joining the legs and an opening in each leg through which a single mounting fastener can extend. When installed with the outside of one leg abutting one conductor, another conductor is clamped between the legs. At least one outer projection (tooth) on the outer face of one leg engages the conductor to which the connector is mounted. At least one inner projection (tooth) on the same leg engages the conductor clamped between the legs. A recess on the inner face of the distal portion of the other leg is configured to cradle the clamped conductor.

17 Claims, 5 Drawing Sheets



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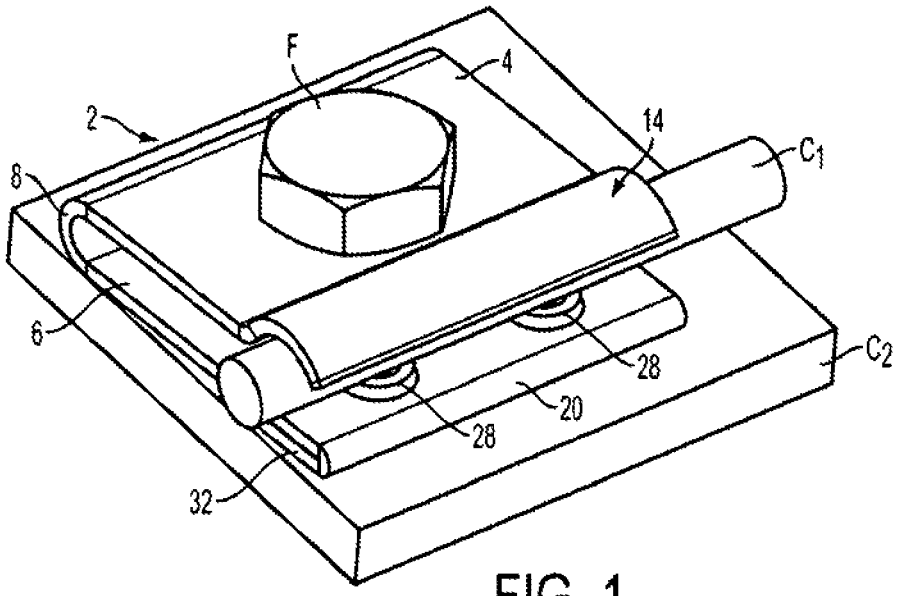

FIG. 1

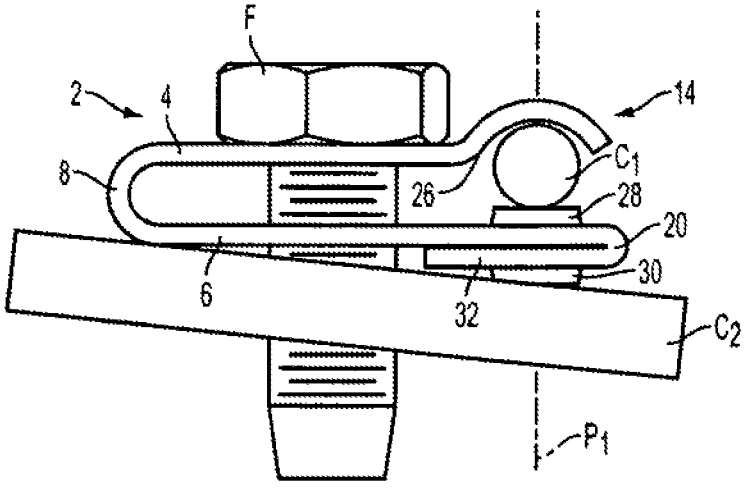

FIG. 2

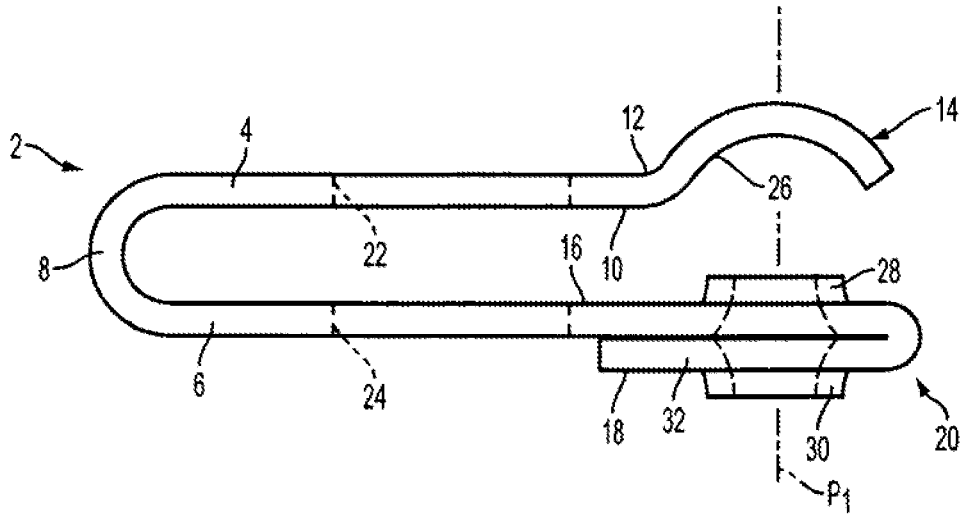

FIG. 3

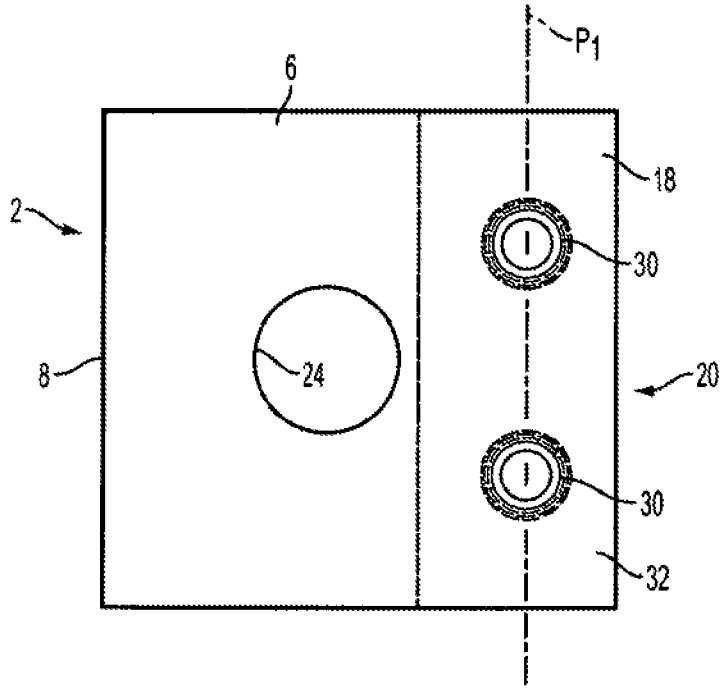

FIG. 4

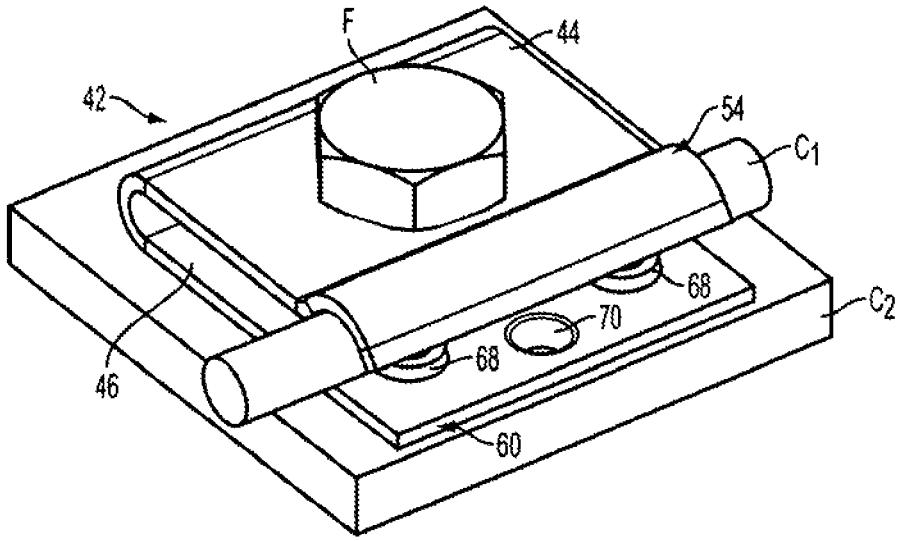

FIG. 5

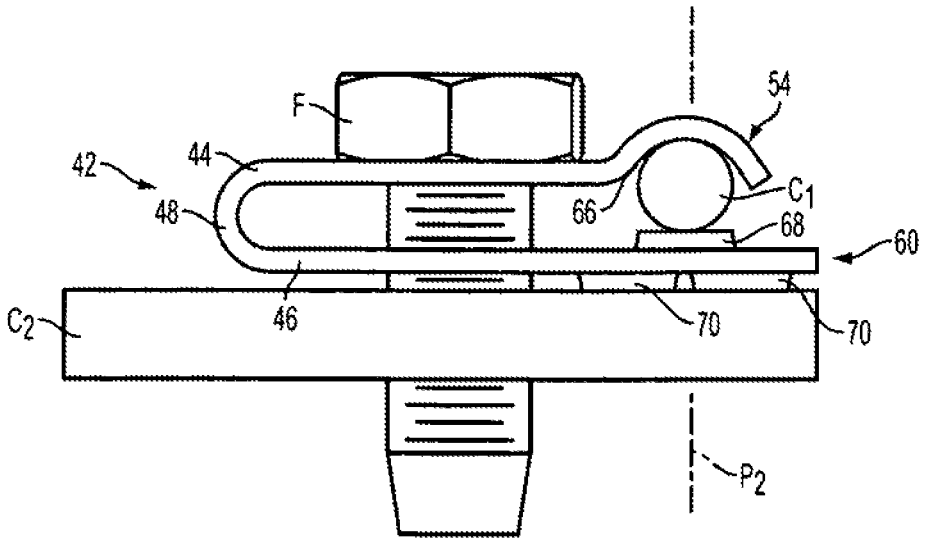

FIG. 6

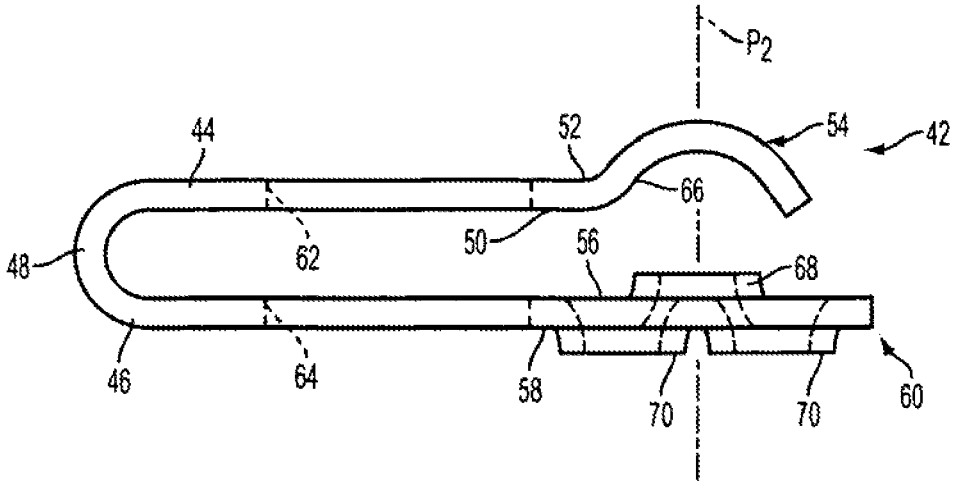
P2
44
52
54
42
66
48
62
50
56
68
46
64
58
70
70
60

FIG. 7

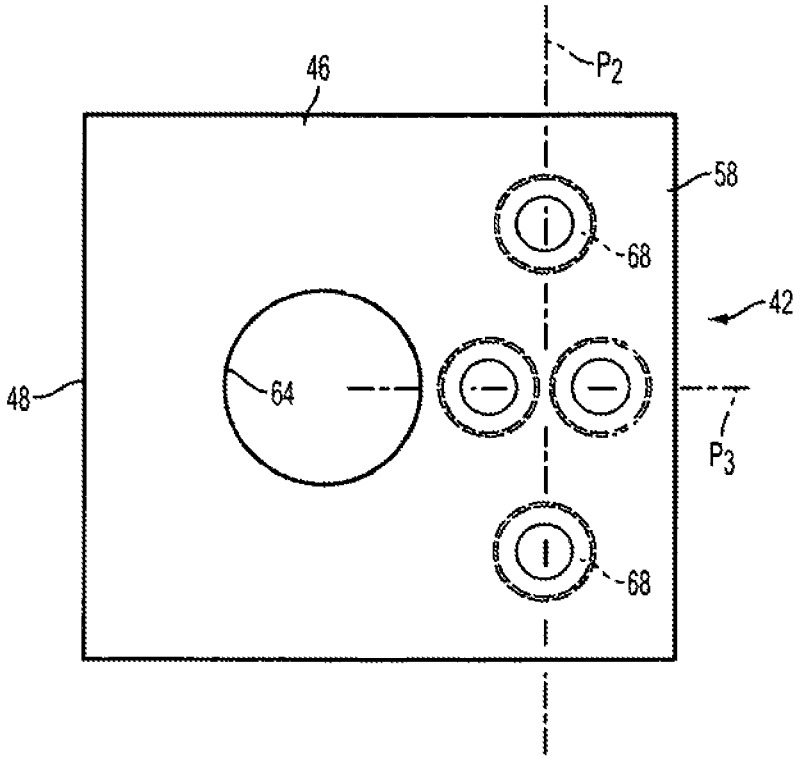
46
P2
58
68
42
48
64
P3
68

FIG. 8

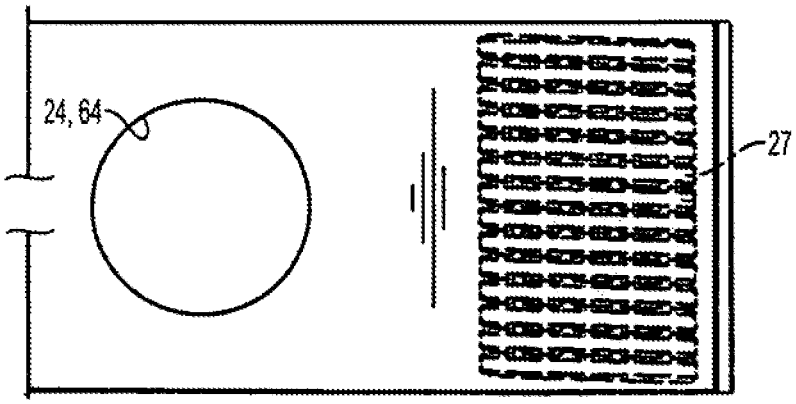

FIG. 9

SINGLE FASTENER ELECTRICAL CONNECTOR

FIELD OF THE INVENTION

The invention relates to connectors for creating an electrical bond between metallic conductors that are to be mechanically fastened together, such as for grounding a metallic structure through a grounding conductor.

BACKGROUND OF THE INVENTION

Safety dictates electrical grounding of exposed metallic parts of equipment housings or frames if there is a possibility that such parts could carry a current. For example, photovoltaic arrays need to be grounded because they produce electricity and are installed outdoors, exposed to the elements. Such arrays typically comprise a number of photovoltaic modules that are assembled onto a larger mounting structure and must be bonded to each other as well as to the grounded mounting structure. Bonded is used here in the technical sense to mean permanently joined to form an electrically conductive path that ensures electrical continuity and has the capacity to safely conduct any current likely to be imposed. The frames of the individual modules and the structural members on which the modules are mounted usually are made of aluminum. The aluminum is anodized to resist corrosion but the anodic coating insulates these pieces so that simple piece-to-piece contact does not electrically bond them together.

A common practice is to install a separate metallic grounding lug on each anodized piece. The grounding lug is mounted to the metal frame of a module by a thread-forming stainless steel screw with a star washer sandwiched between them. The grounding lug accepts a copper wire, which is forced into contact with the grounding lug by a stainless steel set screw. Thus, aside from the mounting screw, there are three parts involved in making such a bonded connection: a lug, a star washer and a set screw. U.S. Pat. No. 8,092,129 to Wiley, et al., which is incorporated by reference herein in its entirety, discloses various types of "bonding washers" that are positioned between the metallic pieces of photovoltaic modules and module supporting structures and pierce the anodic coating to create an electrical bond when the pieces are clamped together. FIGS. 33 and 34 show a grounding lug assembly for use when only one of the metallic pieces has an anodic coating, such as for bonding a ground wire to that piece. That assembly, too, has at least three parts besides the mounting screw.

SUMMARY OF THE INVENTION

The invention is directed to a metallic, one-piece electrical connector configured to receive a fastener and having features that grip and electrically bond two conductors as they are clamped together when the fastener is tightened. For example, the fastener may be threaded, one of the conductors may be a solar panel rack member and the other conductor may be a ground wire.

An electrical connector according to the invention comprises a one-piece, generally U-shaped metal body having a first leg, a second leg and a bight portion joining the legs. Each leg has an inner face, an outer face and a distal portion remote from the bight portion. The inner faces oppose one another and the distal portions are spaced to receive a first conductor between them. A first opening in the first leg and a second opening in the second leg are aligned to permit a fastener to extend through both openings. At least one outer projection is formed on the second leg and extends outward from the second leg's outer face for engaging a second conductor. A recess on the inner face of the distal portion of the first leg cradles the first conductor. At least one inner projection is formed on the distal portion of the second leg and extends inward from its inner face for engaging the first conductor. Thus, when a fastener is placed through the openings and is tightened with the second conductor abutting the outer face of the second leg and the first conductor in the recess, the outer projection(s) on the second leg is are forcibly pressed against the second conductor and the first conductor is clamped between the legs to forcibly press the inner projection(s) against the first conductor.

The inner and outer projections preferably comprise a plurality of teeth adapted to embed themselves in the respective conductors when the fastener is tightened. The distal edges of the teeth preferably are substantially circular. The distal portion of the first leg preferably is outwardly convex, and the recess comprises the concave inside of the distal portion.

In one exemplary embodiment, the recess, the inner teeth and at least one of the outer teeth are substantially coplanar, and at least one of the outer teeth is formed on a (preferably outwardly) folded terminal portion of the second leg disposed substantially parallel to the distal portion of the second leg. Preferably, the inner teeth are respectively aligned with the outer teeth to form sets of oppositely directed teeth.

In another exemplary embodiment, the outer teeth are offset from the plane containing the recess and the inner teeth, preferably lying in a plane substantially normal to the plane containing the recess and the inner teeth.

BRIEF DESCRIPTION OF THE DRAWING

Preferred embodiments of the disclosed invention are described in detail below purely as examples, with reference to the accompanying drawing, in which:

FIG. **1** is a perspective view of a first embodiment of the electrical connector of the invention shown assembled on a portion of a flat conductor and almost fully clamping a round conductor to the flat conductor;

FIG. **2** is a side elevational view of the assembly of FIG. **1**;

FIG. **3** is a side elevational view of the first embodiment of FIG. **1** per se;

FIG. **4** is bottom plan view of the first embodiment of FIG. **3**;

FIG. **5** is a perspective view of a second embodiment of the electrical connector of the invention shown assembled on a portion of a flat conductor and almost fully clamping a round conductor to the flat conductor;

FIG. **6** is a side elevational view of the assembly of FIG. **5**;

FIG. **7** is a side elevational view of the second embodiment of FIG. **4** per se;

FIG. **8** is a bottom plan view of the second embodiment of FIG. **7**; and

FIG. **9** is a detail plan view of an optional knurled clamping surface suitable for inclusion in any embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to FIGS. **1-4**, a first embodiment of the electrical connector of the invention comprises a one-piece,

generally U-shaped body **2** preferably made of stainless steel. Body **2** has a first leg **4**, a second leg **6** and a bight portion **8** joining the legs. First leg **4** has an inner face **10**, an outer face **12** and a distal portion **14** remote from bight portion **8**. Second leg to has an inner face **16**, an outer face **18** and a distal portion **20** remote from bight portion **8**. Inner faces **10**, **16** oppose one another and distal portions **14**, **20** are spaced or can be urged apart to receive a first conductor C_1 between them. Legs **4**, **6** have respective holes **22**, **24** that are aligned to accommodate a fastener F, such as a threaded bolt, for securing the body to a second conductor C_2 with conductor C_1 clamped between the legs.

The distal portion **14** of first leg **4** preferably is curved outward as shown to provide an arcuate recess **26** on its inner face that cradles round conductor C_1. Distal portion **14** may be configured to provide a cradling recess of a different shape, for example, a V-shaped recess (not shown). Knurls **27** (see FIG. **9**) optionally may be formed on the inner surface of recess **26** to enhance the grip on and bond with conductor C_1. Bonding with conductor C_1 primarily occurs at the distal portion **20** of second leg **6** by means of two inner teeth **28** that project from the leg's inner face **16**. One tooth would suffice if it makes a good electrical bond; however, at least two teeth are preferred and all teeth directly oppose the longitudinal center of recess **26**, i.e., the centers of teeth **28** and the center of recess **26** lie in a common plane P_1 (see FIGS. **2-4**).

Bonding with conductor C_2 occurs at the distal portion **20** of second leg **6** by means of two outer teeth **30** that project from the leg's outer face **18**. Teeth **30** are formed on a terminal portion **32** of leg **6** that is folded outward 180° substantially flat against the remainder of distal portion **20**. Here, too, one tooth **30** would suffice if it makes a good electrical bond; however, at least two teeth **30** are preferred, the number being equal to the number of inner teeth **28**. Each outer tooth **30** preferably is aligned with a respective inner tooth **28** so as to form sets of aligned, oppositely directed teeth, all of which lie in common plane P_1. Thus, when fastener F is installed and tightened, the clamping force exerted by the connector on conductors C_1 and C_2 acts directly along common plane P_1, maximizing the penetrating effect of the teeth on their respective conductors.

Referring to FIG. **2**, the outwardly folded terminal portion **32** of second leg **6** results in a thicker distal portion **20** and thus causes second leg **6** to be slightly inclined relative to conductor C_2. As shown, this geometry initially focuses the clamping force of teeth **30** through a smaller area, resulting in an enhanced ability to break anodic coatings. When the fastener is tightened further for full clamping effect (not shown) the sharp distal edge of terminal portion **32** may also penetrate the coating. The clamping force is optimized by keeping the distance from common plane P_1 to bight portion **8** as short as practicable and locating holes **22**, **24** (and hence fastener F) fairly close to common plane P_1, preferably not more than about half the distance from common plane P_1 to bight portion **8**.

Teeth **28** and **30** may be any of the types of teeth disclosed in the aforesaid U.S. Pat. No. 8,092,129 to Wiley, et al., such as those shown in FIGS. 3-8 and described at col. 7, lines 14-31 thereof. The preferred tooth form is circular and the connector may have a thin coating of a material such as chromium or titanium nitride in order to achieve the desired tooth hardness so that the teeth can penetrate anodic coatings and become embedded in the underlying metal.

Referring to FIGS. **5-8**, a second embodiment of the electrical connector of the invention similarly comprises a one-piece, generally U-shaped body **42**, preferably made of stainless steel, having a first leg **44**, a second leg **46** and a bight portion **48** joining the legs. First leg **44** has an inner face **50**, an outer face **52** and a distal portion **54** remote from bight portion **48**. Second leg **46** has an inner face **56**, an outer face **58** and a distal portion **60** remote from bight portion **48**. Inner faces **50**, **56** oppose one another and distal portions **54**, **60** are spaced or can be urged apart to receive a first conductor C_1 between them. Legs **44**, **46** have respective holes **62**, **64** that are aligned and located to accommodate a fastener F as described above in connection with the first embodiment. The distal portion **54** of first leg **44** similarly is preferably curved outward as shown to provide an arcuate recess **66** on its inner face that cradles round conductor C_1. Knurls **27** (see FIG. **9**) and other recess shapes may be used as described above.

Bonding with conductor C_1 in this embodiment is similarly accomplished by means of two inner teeth **68** at the distal portion **60** of second leg **46** that project from the leg's inner face **56**. Here, too, one tooth would suffice if it makes a good electrical bond; however, at least two teeth **68** are preferred and all teeth directly oppose the longitudinal center of recess **66**, i.e., the centers of teeth **68** and the center of recess **66** lie in a common plane P_2 (see FIGS. **6-8**). Bonding with conductor C_2 also occurs at the distal portion **60** of second leg **46** by means of two outer teeth **70** that project from the leg's outer face **58**. In contrast to the first embodiment, however, the distal portion of second leg **46** is not folded; and outer teeth **70** are offset from plane P_2 and are centered along a plane P_3 that is perpendicular to plane P_2 (see FIG. **6**). Tooth design options are preferably the same as those described in connection with the first embodiment.

The one-piece construction and configuration of the above embodiments make installation of these electrical connectors fast and easy: (1) a bolt is placed through the holes in the legs, (2) the legs are spread slightly to embrace conductor C_1, and (3) the bolt is inserted in a predrilled hole in conductor C_2 and driven home to clamp the parts together. Some installers may find it more convenient to reverse steps 1 and 2. Either way, the result is a quick and effective electrical bond.

While preferred embodiments have been chosen to illustrate the electrical connector of the invention, it will be understood by those skilled in the art that various changes and modifications may be made without departing from the scope of the invention as defined by the appended claims.

What is claimed is:

1. An electrical connector for connecting a first conductor to a second conductor when secured by a fastener, comprising:

a one-piece, generally U-shaped metal body having a first leg, a second leg and a bight portion joining said legs, each of said legs having a distal portion remote from said bight portion spaced apart to receive the first conductor therebetween, said second leg distal portion terminating in an outwardly folded terminal portion;

a first opening in said first leg;

a second opening in said second leg passing through said outwardly folded terminal portion, said first and second openings being substantially aligned to permit a fastener to extend therethrough;

at least one outer projection formed on said second leg extending outwardly for engaging the second conductor;

a recess defined by the distal portion of said first leg configured to cradle the first conductor; and

at least one internal projection formed on the distal portion of said second leg and extending inwardly for engaging the first conductor,

whereby, when a fastener extending through said openings is tightened with the second conductor abutting said second leg and the first conductor in said recess, said at least one outer projection is forcibly pressed against the second conductor and the first conductor is clamped by said legs to forcibly press said at least one internal projection against the first conductor.

2. The electrical connector of claim **1**, wherein the distal portion of said first leg is outwardly convex, and said recess comprises the concave inside of said outwardly convex distal portion.

3. The electrical connector of claim **1**, wherein said recess comprises a knurled surface.

4. The electrical connector of claim **1**, wherein said at least one internal projection and said recess are substantially opposed.

5. The electrical connector of claim **4**, wherein said at least one outer projection comprises a plurality of outer teeth, said at least one internal projection comprises a plurality of internal teeth, and each of said teeth has a distal edge adapted to embed itself in a respective conductor when the fastener is tightened.

6. The electrical connector of claim **5**, wherein the distal edge of each of said teeth is substantially circular.

7. The electrical connector of claim **5**, wherein said recess and said internal teeth are substantially coplanar.

8. The electrical connector of claim **7**, wherein said first and second openings are located substantially midway between said bight portion and the plane containing said recess and said internal teeth.

9. The one-piece electrical connector of claim **7**, wherein said recess, said internal teeth and at least one of said outer teeth are substantially coplanar.

10. The one-piece electrical connector of claim **9**, wherein said first and second openings are located substantially midway between said bight portion and the plane containing said recess and said internal teeth.

11. The electrical connector of claim **10**, comprising two internal teeth, and two outer teeth formed on said terminal portion.

12. The electrical connector of claim **11**, wherein said two internal teeth are respectively aligned with said two outer teeth so as to form two sets of oppositely directed teeth.

13. The electrical connector of claim **12**, wherein the distal portion of said first leg is outwardly convex, and said recess comprises the concave inside of said outwardly convex distal portion.

14. The electrical connector of claim **7**, wherein said outer teeth are offset from the plane containing said recess and said internal teeth.

15. The one-piece electrical connector of claim **14**, wherein said first and second openings are located substantially midway between said bight portion and the plane containing said recess and said internal teeth.

16. The electrical connector of claim **14**, wherein said outer teeth lie in a plane that is substantially normal to the plane containing said recess and said internal teeth.

17. The electrical connector of claim **15**, wherein the distal portion of said first leg is outwardly convex, and said recess comprises the concave inside of said outwardly convex distal portion.

* * * * *